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Butting Out: An Analysis of Support for Measures to Address Tobacco Product Waste

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Abstract

Background: Cigarette butts are ubiquitous litter items, causing major environmental damage and imposing significant clean-up costs. Tobacco companies frame smokers as both the cause of this problem and the source of its solution. However, an *extended producer responsibility* perspective challenges this view and holds tobacco companies to account for the full life-cycle costs of tobacco product waste (TPW).

Methods: Using an online cross-sectional survey of 396 New Zealand smokers and 414 non-smokers, we estimated awareness of TPW, attribution of responsibility for TPW, and support for interventions to reduce TPW. Descriptive analyses and logistic regression models examined associations between demographic attributes and smoking behaviours, and perceptions of TPW and potential solutions to this problem.

Results: Most respondents saw butt litter as toxic to the environment and held smokers primarily responsible for creating TPW. However, when knowledge of butt non-biodegradability increased, so too did the proportion holding tobacco companies responsible for TPW. Changes to product design, fines for littering, and expanded smokefree spaces were considered most likely to reduce TPW. Smokers and non-smokers held different views on measures to address TPW, with smokers favouring more educative approaches and non-smokers more restrictive policies.

Conclusions: Strategies to increase awareness of tobacco companies' role in creating TPW could foster political support for producer responsibility measures that require the industry to manage TPW. Nevertheless, policy measures should continue to foster smoking cessation

and decrease uptake, as reducing smoking prevalence presents the best long-term solution to addressing TPW.

INTRODUCTION

Recent estimates suggest global annual consumption of cigarettes now exceeds 5.5 trillion sticks; around three-quarters of smokers litter their cigarette butts, making tobacco product waste (TPW) the most commonly littered item in the world.[1-7] Cigarette butts comprise filters made from non-biodegradable cellulose acetate fibres that create a barrier between loose tobacco and smokers' mouths.[8, 9] Although filters have become widely understood as a barrier that removes toxins, creates a "smoother" smoking experience, and reduces the harms of smoking, they actually provide no health benefits, and inhaled fibres may even harm smokers.[8-12] Filters thus present two serious problems: they fail to reduce smokers' health risks and they accumulate, creating large quantities of non-biodegradable environmental waste.[7, 13]

Several studies have examined tobacco companies' sustained deception of smokers, many of whom still believe filters reduce the toxins they inhale[14] Fewer researchers have examined the environmental damage caused by TPW, though recent studies report specific harms to aquatic animals and contamination of waterways,[7, 15, 16] and note risks to children and animals if they ingest cigarette litter left in playgrounds or parks.[17, 18] Researchers have also documented the substantial costs TPW imposes on local authorities that fund street and amenity clean-up operations, with US estimates suggesting that San Francisco spends between US\$6 million and \$7 million annually to manage TPW.[8, 19] Citizens bear these costs directly, through local taxes, and indirectly, through the despoilment of public amenities.[10] Assessments of the time taken for butts to decompose vary, with studies suggesting limited degradation within two years,[20] and estimates of complete decomposition typically range from 10-15 years to several decades or never, depending on conditions.[13, 21]

Evidence from industry documents shows tobacco companies recognised growing concerns over TPW and researched smokers' environmental concerns. While some companies later considered removing filters, evidence that smokers had become so accustomed to these suggested filter-less cigarettes would not be commercially viable.[10] No company has thus removed filters from the cigarettes they manufacture, leaving a major environmental problem unaddressed.

Beliefs about where responsibility for TPW should lie vary. Those holding smokers primarily responsible for TPW argue smokers should display greater personal accountability, dispose of their butts more thoughtfully, and refrain from littering. Fining smokers caught discarding butts, or rewarding citizens who provide information leading to the arrest of litterers, further reflect the view that smokers are responsible for TPW and should be held accountable for it.[6, 22] Tobacco companies' corporate social responsibility strategies, such as funding "Keep [country] Beautiful" schemes, reinforce this perspective by framing smoking and littering as individual choices.[23, 24] These latter initiatives have successfully deflected responsibility from corporations to smokers, while positioning tobacco companies as mindful corporate citizens.[10, 25, 26] Less punitive, but still focussing on smokers, education programmes and product labelling aims to change individuals' behaviour, albeit using gentler measures,[6, 10] while refundable deposits reimbursed on presentation of collected butts offer a personal and financial incentive to reduce TPW.[23]

By contrast, an extended producer responsibility (EPR) perspective directly challenges notions of personal responsibility and holds tobacco companies to account for the full life-cycle costs and consequences of TPW.[2, 6, 8, 10, 23, 27, 28] This approach focuses attention on the companies that manufacture cigarettes, despite evidence their product causes serious health and

environmental harms.[2, 6, 17, 23, 27, 29] Measures at this end of the responsibility continuum include TPW taxes levied on tobacco companies and hypothecated to support clean-up costs.[19] Other approaches focus on product reformulation, such as making biodegradable filters mandatory.[23] More explicit EPR measures include specific statutes holding tobacco companies responsible for waste resulting from the manufacture or use of their products,[2, 6, 27] and using public nuisance tort law to seek damages covering clean-up costs.[10]

Although the environmental harm caused by TPW is unquestionable, addressing this problem does not appear to be a policy priority, even in New Zealand, a country that has developed a tourism brand based on its ‘clean, green’ identity. Currently, the TPW discourse is dominated by tobacco companies and their argument that smokers are responsible for littering,[5, 8] with little consideration of alternative viewpoints.[6, 10, 17] In this study, we took a broader view by exploring New Zealanders’ perceptions of TPW’s environmental impact, how they attributed responsibility for TPW, and their support for different measures designed to reduce TPW.

METHODS

Our study involved an online panel survey of approximately 800 New Zealanders. Online panels are used increasingly in health research as internet penetration often exceeds landline coverage (92% cf. 86% in New Zealand).[30] New Zealand (NZ) is a highly relevant location in which to examine TPW as, for several years, tourism agencies have promoted NZ as a “clean green” destination with pristine natural environments.[31] Further, NZ has a tobacco endgame goal and the NZ Government aims to reduce smoking prevalence among all population groups to less than five percent (and as close to zero as possible) by 2025.[32]

Sample and Procedure

We recruited a sample of 396 current smokers and 414 non-smokers from Research Now, an online panel owner. Screening questions and age, gender, ethnicity and smoking status quotas were used to recruit a diverse sample comprising current smokers (daily and non-daily) as well as former smokers and never-smokers. We fielded the survey between 5 and 13 November 2017, using the Qualtrics platform. Six thousand five hundred panel members were sent an email inviting them to the survey website. Of these, 958 respondents attempted the survey and 820 completed it (the other 138 respondents were either under 18 years of age or belonged to quotas that had already been filled). Ten respondents were excluded from the sample during data cleaning because of meaningless or irrelevant answers to one or more of the open-ended questions used to probe whether respondents' wished to make additional comments. Supplementary File 2 outlines the sampling process and Supplementary File 3 contains the survey instrument.

Instrument

Respondents answered questions probing how they defined litter, their experiences of litter in different settings, and their perceptions of TPW and its effects on the environment. Attitude and belief questions examined respondents' perceptions of TPW's effects, their knowledge of butt biodegradability, views towards people who discard butts as litter, and their perceptions of where responsibility for TPW should lie. Because knowledge of TPW's biodegradability tends to be low, we provided respondents with information about how long it takes cigarette butts to decompose in the environment and then reassessed their views on where responsibility for managing TPW should lie. Respondents used five-point scales to assess the likely effectiveness of potential responses to TPW. Finally, all respondents provided demographic data, and smokers provided details of their tobacco use.

Data Analyses

We undertook preliminary descriptive analyses and then developed separate logistic regression models to examine the associations between smoking behaviour, TPW disposal behaviours, demographic attributes, beliefs and attitudes to, and knowledge of, TPW, allocation of responsibility for TPW, and potential solutions. Using significant variables ($p < 0.05$) from these individual models, we developed multi-variable logistic regression models to estimate determinants of perceived responsibility for TPW and support for different measures that could address TPW. All analyses were undertaken using SPSS version 24.

RESULTS

Sample composition

Supplementary File 1 contains the demographic characteristics of the smoker and non-smoker subsamples; these samples are very similar, though there are relatively more younger smokers than younger non-smokers and fewer older smokers, reflecting the difference in the demographic profile of smokers and non-smokers. In the results that follow, we have weighted the *total sample* to achieve the correct population ratio of smokers to non-smokers. This process reduced the total sample size to 492; 414 non-smokers and 78 smokers.

Perceptions of litter and TPW

Over 90% of respondents viewed plastic bags and bottles, fast food packaging, cigarette butts and packs, and broken glass as litter, with little or no differences between smokers and non-smokers. More than 80% perceived plastic to be a major threat to the environment, while only around a third (36%) viewed cigarette butts in the same way (though non-smokers were marginally more likely than smokers to view butts as a major environmental threat; (Supplementary File 4 contains full details of these findings).

When presented with more specific statements about TPW, most respondents agreed that cigarette butts were toxic to the environment and harmful to animals, fish and sea life. Non-smokers were significantly more likely than smokers to agree that cigarette butts are toxic to the environment (75% cf. 60%) and significantly less likely than smokers to see TPW as biodegradable (13% cf. 20%). Table 1 contains these findings.

Table 1: Perceptions of cigarette butts

Statement	Proportion who agree or strongly agree		
	Smokers (n=396) % & (95% CI)	Non-smokers (n=414) % & (95% CI)	Total Sample ¹ (n=492) % & (95% CI)
Cigarette butts are toxic to the environment	60.3 ² (55.5-65.1)	74.7 ² (70.5-78.9)	72.4 (68.5-76.4)
Cigarette butts are dangerous if thrown in a rubbish tin	60.6 (55.8-65.4)	61.1 (56.4-65.8)	61.0 (56.7-65.3)
Cigarette butts are harmless to fish and sea life	24.5 (20.3-28.7)	21.8 (17.8-25.8)	22.2 (18.5-25.9)
Cigarette butts are harmless to animals	22.7 (18.6-26.8)	17.9 (14.2-21.6)	18.6 (15.2-22.0)
Cigarette butts are biodegradable	20.2 ³ (16.3-24.2)	12.5 ³ (9.3-15.7)	13.7 (10.7-16.7)

1. Sample weighted by smoking status.
2. Non-smokers significantly higher attribution than smokers ($p < 0.05$)
3. Non-smokers significantly lower attribution than smokers ($p < 0.05$)

We then examined which actors respondents saw as responsible for creating and addressing TPW. As Table 2 shows, most respondents regarded smokers as primarily responsible for creating TPW (85%), with non-smokers significantly more likely to hold this view than smokers (88% cf. 71%). Non-smokers were also significantly more likely than smokers to hold tobacco companies responsible for creating TPW (55% cf. 40%), though they were significantly less likely than smokers to hold city councils responsible (18% cf. 30%).

Respondents' views on where responsibility for managing TPW should lie changed after they were told how long it takes for butts to decompose. Both smokers and non-smokers became significantly more likely to hold tobacco companies responsible for TPW. The proportion of smokers holding this view increased from 41% to 59% while the proportion for non-smokers increased from 57% to 76%. The proportion of non-smokers viewing the Government and city councils as responsible for addressing TPW also increased significantly (from 35% to 47%, and from 26% to 40%, respectively). Neither smokers nor non-smokers changed their views on smokers' responsibility for addressing TPW after they received the biodegradability information.

Table 2. Perceived responsibility for cigarette butt litter

Group Responsible	Proportion attributing a great deal of responsibility for								
	Creating the problem			Fixing the problem			Fixing the problem With cigarette butt facts ¹		
	Smokers (n=396) % (95% CI)	Non-smokers (n=414) % (95% CI)	Total ² (n=492) % (95% CI)	Smokers (n=396) % (95% CI)	Non-smokers (n=414) % (95% CI)	Total ² (n=492) % (95% CI)	Smokers (n=396) % (95% CI)	Non-smokers (n=414) % (95% CI)	Total ² (n=492) % (95% CI)
Smokers	71.0 (66.5-75.5)	88.2 ³ (85.1-91.3)	85.4 (82.3-88.5)	71.7 (67.3-76.1)	86.7 ³ (83.4-90.0)	84.3 (81.1-87.5)	75.8 (71.6-80.0)	86.0 ³ (82.7-89.3)	81.0 (77.5-84.5)
Cigarette companies	40.4 (35.6-45.2)	54.8 ³ (50.0-59.6)	52.5 (48.1-56.9)	40.9 (36.1-45.7)	56.5 ³ (51.7-61.3)	54.0 (49.6-58.4)	58.6 ⁵ (53.8-63.5)	76.3 ^{3,5} (72.2-80.4)	73.5 (69.6-77.4)
Government	22.0 (17.9-26.1)	26.1 (21.9-30.3)	25.4 (21.6-29.3)	28.3 (23.9-32.7)	35.3 ⁵ (30.7-39.9)	34.2 (30.0-38.4)	35.9 (31.2-40.6)	47.3 ^{3,5} (42.5-52.1)	41.7 (37.3-46.1)
City councils	30.3 (25.8-34.8)	18.1 ⁴ (14.4-21.8)	20.0 (16.5-23.5)	27.0 (22.6-31.4)	26.1 (21.9-30.3)	26.2 (22.3-30.1)	33.8 (29.1-38.5)	40.1 ⁵ (35.4-44.8)	37.0 (32.7-41.3)

1. Response after respondents were presented with facts about the biodegradability and efficacy of filters
2. Sample weighted by smoking status.
3. Non-smokers significantly higher attribution than smokers (p<.05)
4. Non-smokers significantly lower attribution than smokers (p<.05)
5. Significant increase in proportion holding group responsible following receipt of TPW information.

Perceived effectiveness of different measures

We next examined the perceived effectiveness of measures that could potentially address TPW. Table 3 shows that, among the more individually-oriented measures, those regarded overall as likely to have the greatest impact on TPW included fines for butt litterers and not allowing smoking in public outdoor spaces, with non-smokers significantly more likely to support the latter than smokers (73% cf. 56%). Smokers were significantly more likely than non-smokers to view on-pack information as an effective approach to addressing TPW (55% cf. 38%), and marginally more likely than non-smokers to see advertising campaigns as effective (72% cf. 63%).

Responses to measures requiring product modifications, or that placed more responsibility on tobacco companies, showed fewer differences by smoking status. Smokers and non-smokers alike (over 80% in total) saw a new law requiring filters to be biodegradable as most effective in addressing TPW. Support for other measures was also similar across smoking groups, though smokers were significantly less likely to support a law banning the use of filters in cigarettes (37% cf. 57%) or imposing a NZ\$2 levy (approximately USD1.35) on behalf of local councils to fund clean-up costs (37% cf. 54%).

Table 3: Perceived effectiveness of measures to address TPW

Measure assessed	Proportion of ‘Likely plus Very Likely’ Responses		
	Smokers (n=396) % (95% CI)	Non-smokers (n=414) % (95% CI)	Total sample ¹ (n=492) % (95% CI)
Personal Responsibility Measures			
Fines for people caught throwing their butts away	67.9 (63.3-72.5)	74.6 (70.4-78.8)	73.6 (69.7-77.5)
Not allowing smoking in any public outdoor spaces to avoid butt litter in those areas	56.1 (51.2-61.0)	72.9² (68.6-77.2)	70.3 (66.3-74.3)
Advertising campaigns to help people understand the environmental harm caused by butt litter	72.0³ (67.6-76.4)	63.0 (58.4-67.7)	64.5 (60.3-68.7)
Adding a \$2 deposit to cigarettes that people would get refunded when they returned their pack and butts to a retailer	51.0 (46.1-55.9)	56.0 (51.2-60.8)	55.2 (50.8-59.6)
Labels on tobacco packages telling people about the harm butt litter causes and asking them to dispose of their butts safely	54.8² (49.9-59.7)	38.2 (33.5-42.9)	40.8 (36.5-45.1)
Extended Producer Responsibility Measures			
A new law requiring all cigarette filters to be biodegradable	81.3 (77.5-85.1)	81.2 (77.4-85.0)	81.2 (77.8-84.7)
An annual fee tobacco companies would have to pay (based on their market share) that would be used to meet the cost cleaning up tobacco litter	61.6 (56.8-66.4)	67.4 (62.6-72.2)	66.5 (62.3-70.7)
A new law that would require tobacco companies to be responsible for collecting and disposing of tobacco litter	45.7 (40.8-50.6)	53.9 (49.1-58.7)	52.6 (48.2-57.0)
A new law that would not allow the sale of cigarette filters and cigarettes with filters	37.4 (32.6-42.2)	57.2² (52.4-62.0)	54.1 (49.7-58.5)
A price increase of \$2 on all tobacco products, given to local authorities to meet the cost of cleaning up tobacco litter	36.9 (32.2-41.7)	54.1² (49.3-58.9)	51.4 (47.0-55.8)

1. Sample weighted by smoking status

2. Estimates shown in bold indicate significant differences between smokers and non-smokers (p<0.05).

3. Difference between smokers and non-smokers marginally significant (p<0.10).

Determinants of effectiveness of individually-oriented interventions

To address the final research question, we developed multi-variable logistic regression models to estimate associations between demographics and other variables, and the perceived effectiveness of different interventions. Table 4 contains results relating to the more individually-oriented interventions. As noted above, smokers were significantly less likely than non-smokers to support fines or not allowing smoking in public outdoor areas, and marginally less likely to support a butt refund scheme. However, smokers were significantly more likely than non-smokers to support educational interventions, such as advertising or on-pack information. There were no significant differences by gender, but Māori (the indigenous peoples of New Zealand) were significantly less likely to see fines as effective in reducing TPW though, with Pacific respondents, were significantly more likely to see a butt refund scheme as effective. Pacific respondents were also more than twice as likely as European/ other and Māori to consider educational initiatives as effective. Older participants were significantly less likely than younger participants to consider a butt refund scheme effective. There were no consistent differences by education.

Table 4: Determinants of perceived effectiveness of individually-oriented policies to reduce TPW¹

Independent Variables	Fines for people caught throwing their butts away	Adding a \$2 deposit to cigarettes, refundable when packs and butts were returned to a retailer	Not allowing smoking in any public outdoor spaces to avoid butt litter in those areas	Advertising campaigns to help people understand the environmental harm caused by butt litter	Labels on tobacco packages telling people about the harm butt litter causes and asking them to dispose of their butts safely
	Adjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Smoker status					
Non-smoker	1.00	1.00	1.00	1.00	1.00
Smoker	0.71** (0.52-0.98)	0.78* (0.58-1.04)	0.48*** (0.36-0.65)	1.59** (1.17-2.15)	1.93*** (1.45-2.57)
Gender					
Female	1.00	1.00	1.00	1.00	1.00
Male	0.84 (0.62-1.15)	1.01 (0.76-1.35)	0.97 (0.73-1.31)	1.08 (0.80-1.45)	1.00 (0.75-1.33)
Ethnicity					
European/Other	1.00	1.00	1.00	1.00	1.00
Maori	0.66** (0.48-0.92)	1.38** (1.02-1.88)	0.88 (0.64-1.21)	1.04 (0.74-1.46)	1.23 (0.91-1.68)
Pacific	0.77 (0.49-1.70)	2.63*** (1.41-4.92)	1.34 (0.73-2.45)	2.72*** (1.33-5.55)	2.33*** (1.32-4.12)
Education					
Low	1.00	1.00	1.00	1.00	1.00
Medium	1.46** (1.01-2.09)	1.22 (0.88-1.69)	1.32 (0.94-1.86)	1.04 (0.74-1.46)	.91 (0.65-1.26)
High	1.09 (0.72-1.65)	1.51*** (1.03-2.23)	1.14 (0.77-1.69)	1.35 (0.90-2.03)	0.93 (0.63-1.36)
Age					
Under 35	1.00	1.00	1.00	1.00	1.00
35 to 54	0.65** (0.45-0.94)	0.58*** (0.42-0.83)	0.85 (0.60-1.21)	0.89 (0.62-1.27)	0.82 (0.59-1.14)
55 and older	0.79 (0.53-1.17)	0.35*** (0.24-0.50)	0.98 (0.67-1.43)	1.03 (0.70-1.50)	0.68** (0.47-0.97)

*Coefficient significant at p<.10 **Coefficient significant at p<.05 ***Coefficient significant at p<.01

1. Preference for different measures (1= perceived as likely or very likely to reduce litter; 0 = all other responses).

Finally, we examined determinants of perceived effectiveness for measures focussing on product change or direct producer liability. Aside from a proposed law mandating biodegradable filters, which smokers and non-smokers viewed similarly, smokers were

significantly less likely to perceive any of the other measures tested as likely to address TPW. There were no differences by gender, though Māori and Pacific participants were significantly more likely than non-Māori to regard a law holding tobacco companies responsible for addressing TPW, as effective. Māori and Pacific were less likely than European/ other ethnicities to view mandatory biodegradable filters as effective, and Māori were also significantly less likely than other ethnicities to support laws disallowing the sale of cigarettes with filters. Respondents with medium and high education levels were generally more likely than those with lower education to see all measures requiring product changes or greater industry accountability as effective, though not all differences were significant. We observed significant age associations for all measures except a law mandating biodegradable filters; in each case, increasing age was associated with decreasing perceived effectiveness. Table 5 contains these results.

Table 5: Perceived effectiveness of product stewardship policies to reduce cigarette butt litter

Independent Variables	A new law requiring all cigarette filters to be biodegradable	An annual fee tobacco companies would have to pay that would be used to meet the cost cleaning up tobacco litter	A new law that would not allow the sale of cigarette filters and cigarettes with filters	A new law requiring tobacco companies to be responsible for collecting and disposing of tobacco litter	A price increase of \$2 on all tobacco products, given to local authorities to meet the cost of cleaning up tobacco litter
	Adjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Smoker status					
Non-smoker	1.00	1.00	1.00	1.00	1.00
Smoker	1.02 (0.71-1.47)	0.76* (0.50-1.03)	.44*** (0.33-0.59)	0.66*** (0.51-0.93)	0.49*** (0.37-0.66)
Gender					
Female	1.00	1.00	1.00	1.00	1.00
Male	1.04 (0.72-1.47)	0.87 (0.65-1.17)	0.92 (0.69-1.22)	1.01 (0.76-1.35)	0.91 (0.69-1.21)
Ethnicity					
European/Other	1.00	1.00	1.00	1.00	1.00
Maori	0.71* (0.48-1.04)	1.10 (0.80-1.51)	0.68** (0.50-0.91)	1.48** (1.09-2.02)	1.19 (0.88-1.62)
Pacific	0.54* (0.28-1.02)	1.69 (0.89-3.22)	0.91 (0.52-1.59)	2.29*** (1.32-4.35)	1.25 (0.72-2.17)
Education					
Low	1.00	1.00	1.00	1.00	1.00
Medium	1.82*** (1.19-2.80)	1.36* (0.97-1.90)	1.12 (0.80-1.55)	1.41** (1.01-1.97)	1.21 (0.88-1.69)
High	1.52* (0.93-2.47)	1.55* (1.04-2.23)	1.60** (1.09-2.34)	1.36 (0.93-2.00)	1.56** (1.07-2.28)
Age					
Under 35	1.00	1.00	1.00	1.00	1.00
35 to 54	0.82 (0.53-1.27)	0.54*** (0.38-0.77)	0.83 (0.59-1.17)	0.55*** (0.39-0.77)	0.91 (0.65-1.28)
55 and older	0.69 (0.44-1.08)	0.44*** (0.31-0.65)	0.57*** (0.41-0.84)	0.31*** (0.21-0.44)	0.60*** (0.42-0.86)

*Coefficient significant at p<.10 **Coefficient significant at p<.05 ***Coefficient significant at p<.01

DISCUSSION

Tobacco product waste constitutes a major environmental problem and should be a key concern in a country like New Zealand, whose tourism brand draws on a '100% pure' identity.[31, 33] Despite increasing awareness of the discrepancy between this position and serious environmental problems, only a minority of our respondents (36%) perceived TPW as a *major* environmental threat.

Respondents instead regarded plastic bags and bottles, and fast-food packaging - large and visually obtrusive items that have featured in anti-litter social marketing campaigns - as more serious environmental threats. Using a size heuristic, respondents appeared to interpret item size as an indication of the threat presented, irrespective of product composition or frequency of littering.[35, 36] Yet, despite the stronger visual presence of plastic bags and bottles, and fast food packaging, small-item litter actually constitutes more than 95% of the rubbish despoiling NZ public spaces, with TPW constituting the vast majority of this litter.[37]

Most respondents, particularly non-smokers, held smokers responsible for TPW, which may reflect the neo-liberal "personal responsibility" discourse that has dominated political thinking in NZ over the last decade. Nonetheless, a small majority also held tobacco companies responsible for TPW, and that majority increased significantly among both smokers and non-smokers once they learned that butt litter was not biodegradable.

While non-smokers were more likely to support punitive measures, such as fines for littering, or norms-oriented approaches, such as increasing or enlarging smokefree areas, smokers favoured educative approaches. This difference may reflect a genuine desire among smokers for greater knowledge that, over time, may challenge existing norms and promote new butt disposal practices. However, given many smokers report avoiding or ignoring on-pack health

warnings, support for on-pack labels or education campaigns promoting environmental messages may also reflect a wish for the least intrusive intervention [38].

The discrepancy between respondents' perceptions and TPW's actual environmental effects highlights the considerable knowledge gap that exists. While education campaigns typically reinforce existing behaviours rather than introduce entirely new practices [39, 40], the extent of misunderstanding suggests increasing knowledge of TPW's environmental impact could have a modest effect on littering. However, social factors could inhibit behaviour change as smokers may discard butts immediately to rid themselves of an object that attracts social disapproval.[8] In the longer term, raising awareness of TPW's environmental impact, and the tobacco industry's role in creating this problem, could foster political support for measures that hold tobacco companies responsible for the costs of managing TPW.

Alliances with environmental organisations could support smokefree arguments, given the environmental damage caused by cigarette butts. However, groups such as 'Keep [country] Beautiful', which operate in many countries, accept tobacco industry funding. Their actions enable tobacco companies to claim their social responsibility initiatives address environmental concerns and obviate policy measures.[41]

Campaigns to expose tobacco industry CSR strategies could help address these problems, and social marketing campaigns aimed at changing butt disposal practices should expose the industry's role in creating TPW. Framing smokers as primarily responsible for TPW could increase the stigma they experience, reinforce stereotypes that they are lazy, uncaring, and dirty, and potentially elicit reactance and entrench smoking patterns.[42-46] By challenging framings that focus solely on smokers, industry exposure campaigns could help reduce the imbalance in perceived responsibility between smokers and cigarette companies, and initiate a wider debate over how TPW should be managed. Relocating responsibility for TPW to tobacco

companies may also reduce the alienation that stigma creates, increase smokers' self-efficacy, and potentially increase the likelihood they consider quitting, an outcome that would reduce the source of TPW [47].

Although it may seem in their interests to allocate responsibility for TPW to other actors, smokers were less likely than non-smokers to support product changes or measures holding tobacco companies to account. Future work could explore whether smokers' resistance to change reflects beliefs that filters reduce their risk of disease caused by smoking, or more functional attributes, such as creating a barrier between their mouth and tobacco strands. Nonetheless, both smokers and non-smokers supported modifying cigarette filters to ensure these were biodegradable, though qualitative work has found that smokers queried potential cost implications.[48] Earlier work has questioned whether smokers would accept biodegradable filters,[10] though technological advances since the studies reported may have addressed the concerns noted. Both smokers and non-smokers also questioned whether biodegradable filters could increase butt litter and impede development of careful disposal practices.[48] Qualitative analyses suggest allocation of responsibility for TPW involves complex trade-offs, including consideration of how different measures could affect the cost of tobacco.[48] If participants thought requiring tobacco companies to fund TPW clean-up operations might ultimately increase the cost of tobacco, they may dispose of butts more mindfully in the hope of maintaining existing prices.

These complex negotiations bring to light unintended outcomes that may affect support for measures to reduce TPW, if these are perceived as likely to increase tobacco prices, which are already high in NZ by international standards. For example, in 2018, a pack of 20 cigarettes cost ~NZ\$26.00 and rising tobacco costs have led some smokers to take extreme economising

measures.[49] A strategic approach, for example, hypothecating the considerable revenue generated by tobacco excise tax to provide more extensive cessation services, could reduce smoking prevalence. Such outcomes could complement state-run Quitline services by funding community-led initiatives that recognise different smoker groups and the need for more diverse cessation services thus assisting the many smokers who regret smoking and who, through quitting, would avoid the burden imposed by tobacco costs.[50, 51]

Our study has some limitations. While online panels recruit widely to provide diverse samples, their members are self-selected; nonetheless, our sample was selected randomly from the panel, in line with practices adopted by other researchers using panel-based samples.[52] We tested measures identified in earlier studies and following in-depth interviews with both smokers and non-smokers,[48] but note that these represent a sub-set of all possible interventions. Future work could, for example, test more diverse tax and levy options to assess how intervention attributes and framing affect perceived effectiveness and likely support. Further research could also explore how policy-makers and advocates view the options we tested. As well as providing insights into the specific problem TPW poses, these findings could inform wider debates, such as the allocation of individual and corporate responsibility in addressing climate change.

The study has some important strengths. To our knowledge, it is the first to test a comprehensive set of interventions ranging from individually-focussed to producer-responsibility measures. It is also the first to test how introducing knowledge of cigarette filters' environmental impact affects perceptions of TPW management strategies. Future work could probe whether smokers see filters as providing important benefits, identify the erroneous beliefs held, and inform social marketing and advocacy campaigns.

Our findings illustrate the complexity of developing TPW management strategies; rather than identify a single solution, we suggest an integrated strategy, drawing on what Rothschild referred to as “carrots, sticks, and promises” [39], could reduce TPW in the medium term. Increasing knowledge of TPW’s environmental impact could provide a platform for social marketing interventions that identify and reinforce new behavior patterns, and pave the way for policies that more directly shape behavior. Nevertheless, reducing smoker numbers is the ultimate longer-term solution to reducing TPW and remains the most effective way of managing social, health and economic inequities caused by tobacco companies or arising unintentionally from policy measures.[53] Yet, while reducing smoking prevalence remains the primary goal, the challenges posed by TPW create an opportunity to expose industry practices, and develop public and political support for more robust tobacco control interventions.

What this paper adds

- Tobacco companies use non-biodegradable cigarette filters despite evidence these do not reduce the harms smokers face and represent a major environmental hazard.
- Although smokers are typically seen as responsible for tobacco product waste (TPW), an extended producer responsibility framework suggests tobacco companies should be held accountable for the costs of managing this waste.
- Increasing knowledge of the environmental harm caused by cigarette filters increases the proportion of smokers and non-smokers holding tobacco companies responsible for managing TPW.
- Requiring cigarettes to contain biodegradable filters, fining smokers who litter cigarette butts, and expanding smokefree outdoor areas were seen as the measures most likely to reduce TPW, though reducing smoking prevalence presents the best long-term solution to addressing TPW.

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